INTEGRATED ADVANCED NATURAL WASTEWATER TREATMENT SYSTEM FOR SMALL COMMUNITIES

By

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Broad Societal Implications

- Knowledge base: **better comprehension of nature, life**
- New technologies and products: ~ $2.5 trillion / year by 2015

  Would require worldwide ~ 2 million nanotech workers
- Improved healthcare: **extend life-span, its quality, physical capabilities**
- Sustainability: **agriculture, food, water, energy, materials, environment; ex: lighting energy reduction ~ 10% or** $100B/y

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Objective

Performance evaluation of waste stabilization pond, overland flow and wetland system under seasonal variations of

1) Temperature

2) Flow, and

3) Organic Loading Rates

Facility Description

The Wastewater treatment system consists of:

- Two-cell waste stabilization pond
- An overland flow treatment system
  - **Two fields (130 m x 46m each)**
- Wetland system
  - Two sub-surface cells
  - Two Free-water surface cells
  - Each cell is 36 m x 32 m

Plant Schematic Diagram

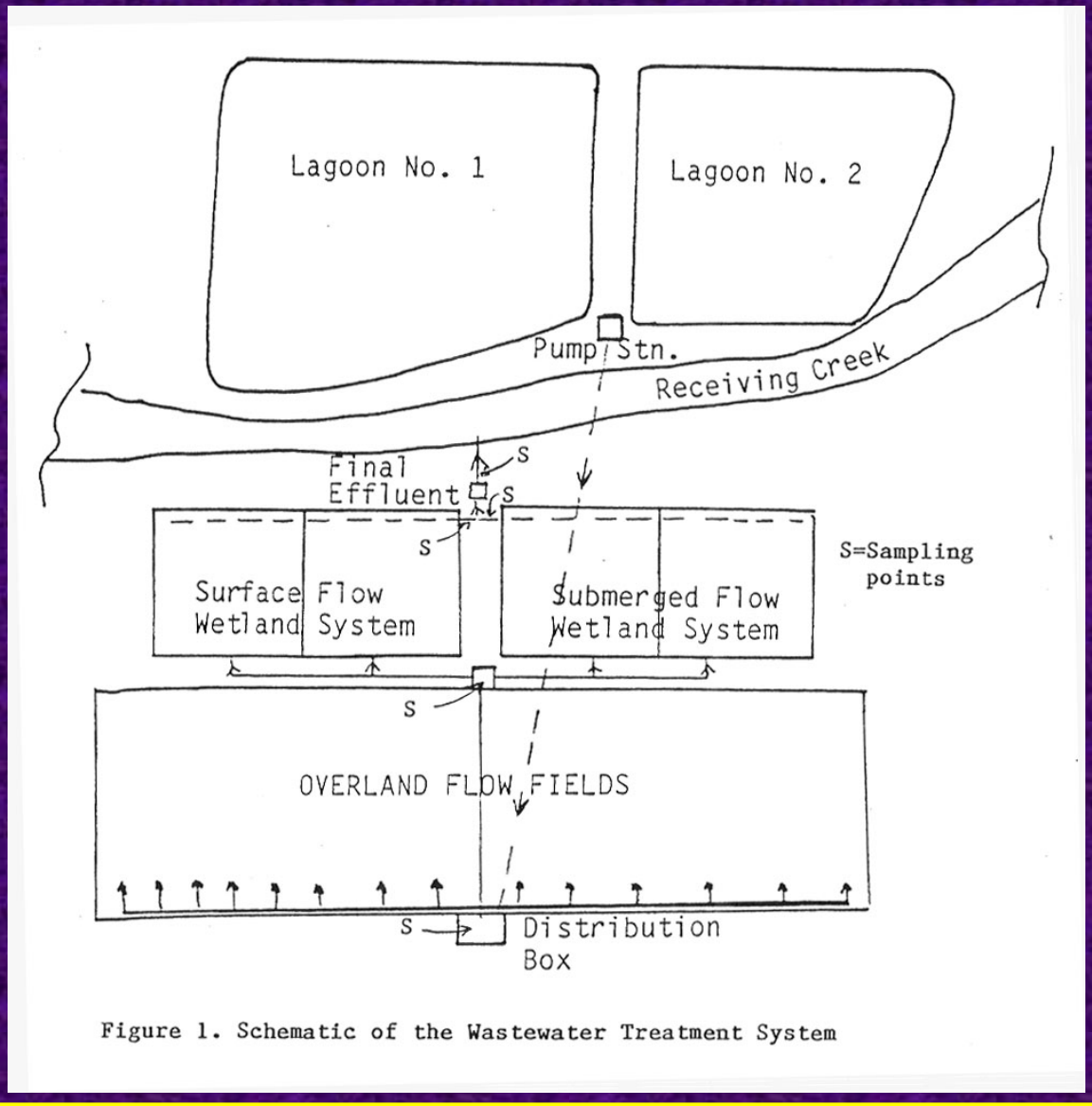


Figure 1. Schematic of the Wastewater Treatment System

Design Flow

Population	900
Design Flow	80,000 GPD

Average Monthly Effluent Limits

BOD_5,	45 MG/L
TSS,	70 MG/L

There are no effluent NH4-N and P limits.

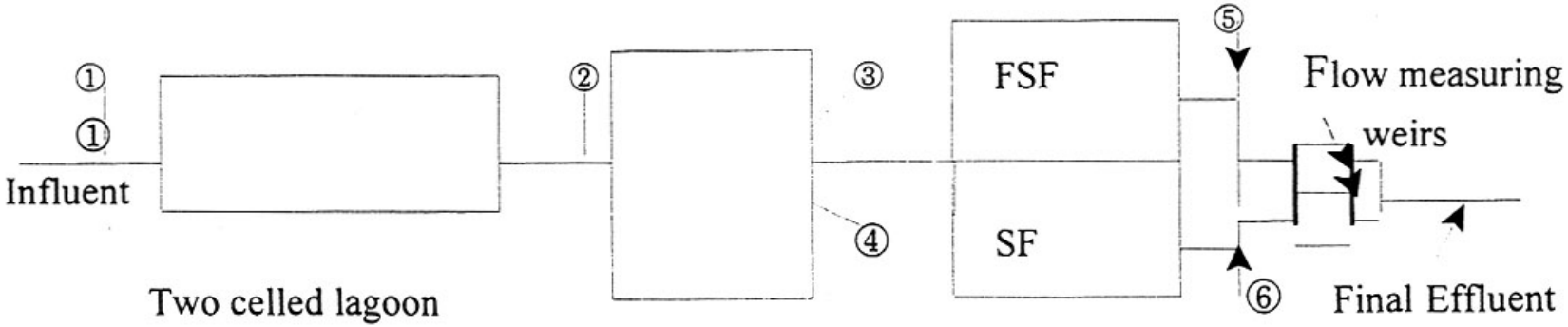
Sampling

Weekly daily grab samples were collected at the following locations:

- Influent to lagoons
- Lagoon effluent
- Overland flow effluent
- Sub-surface wetland effluent
- Free-water surface wetland effluent

Schematic Sampling Locations

Figure 1. Schematic diagram of the wastewater treatment system



Sample locations: ① =influent;
②= inflow to OF fields
③ = effluent from OF field north
④ = effluent from OF field south
⑤ = effluent from wetland free surface flow(FSF)
⑥ = effluent from wetland submerged flow (SF)

Sampling Analysis

The samples collected were analyzed for the following parameters according to standard methods.

- Total BOD_5
- Total suspended solids
- Nitrogen (Nitrate, Nitrate, and Ammonia)
- Phosphorus
- Dissolved oxygen
- PH
- Temperature

Table 1 BOD Removal Data

Month	No. of Samples	BOD Conc. (mg/L)					Average Temp. (C)	% Red Lagoon	% Red OFF	% Red. FWS	% Red. SFS	Total % Red. FWS/SFS
		1*	2*	3*	4*	5*						
Jun-98	3	110	29	19	8.5	16	19.1	73	35	55	16	92/85
Jul-98	2	27	28	14	13	15.5	23.5	-4	50	7	-11	52/43
Aug-98	1	266	72	18		27	24	73	75		-50	/90
Sep-98	3	403	50	17	15	20	21.4	88	66	12	-018	96/95
Oct-98	5	230	42	13	13	14	14.9	82	69	0	-8	94/94
Nov-98	3	230	58	27	12	17	9	75	53	56	37	95/93
Jan-99	2	98	73	16		23	5.6	26	78		-44	/77
Feb-99	3	48	31	12			3	35	61			
Mar-99	2		53	23	18		8.4		57	22		
1*=Sewer Effluent												
2*=Lagoon Effluent												
3*=OFF Effluent												
4*=FWS Effluent												
5*=SFS Effluent												
(-)Negative Number = Percent Increase												

Table 1 - BOD_5 Removal-Summer Performance Data (1998)

DATE	Lagoon Influent MG/L	Lagoon Effluent MG/L	Overland Effluent MG/L	Wetland Effluent MG/L	Percent Removal %
May 26	175	31	28	17	90
June 8	100	29	29	14	86
June 15	96	21	7	3	96
June 24	120	38	21	20	83
July 1	27	21	7	7	74
July 8	120	21	12	10	92

Wastewater temperature range 15-27 °C

Table 2 Suspended Solids Removal Data

Month	No. of Samples	TSS Conc. (mg/L)					Average Temp. (C)	% Red Lagoon	% Red OFF	% Red. FWS	% Red. SFS	Total % Red. FWS/SFS
		1*	2*	3*	4*	5*						
Jun-98	3	91	55	21	3	5	19.1	40	62	86	76	97/95
Jul-98	2	55	55	7	32	1	23.5	0	87	-357	86	42/98
Aug-98	1	128	67	15		1	24	48	78		93	/99
Sep-98	3	333	170	13	6	4	21.4	49	92	54	69	98/99
Oct-98	5	167	76	10	12	4	14.9	54	87	-20	60	93/98
Nov-98	3	96	75	37	8	24	9	22	51	78	35	92/75
Jan-99	2	79	17	4		8	5.6	78	76		-100	/90
Feb-99	3	78	19	4.7			3	76	75			
Mar-99	2		41	10	7		8.4		76	30		
1* = Sewer Effluent												
2* = Lagoon Effluent												
3* = OFF Effluent												
4* = FWS Effluent												
5* = SFS Effluent												
(-) Negative Number= Percent Increase												

Table 2 - TSS Removal - Summer Performance Data (1998)

DATE	Lagoon Influent MG/L	Lagoon Effluent MG/L	Overland Effluent MG/L	Wetland Effluent MG/L	Percent Removal %
May 26	71	38	42	3	96
June 8	77	87	28	3	96
June 15	72	41	21	2	97
June 24	104	37	13	5	95
July 1	55	76	12	1	98
July 15	64	34	2	1	98

Wastewater temperature range 15-27 °C

Table 3 –Ammonia Nitrogen

Month	No. of Samples	Ammonia Nitrogen. (mg/L)					Average Temp. (C)	% Red Lagoon	% Red OFF	% Red. FWS	% Red. SFS	Total % Red. FWS/SFS
		1*	2*	3*	4*	5*						
Jun-98	1	10.8	0.4	1.8	3.3	2.3	19.1	96	-350	-83	-28	69/79
Jul-98	2	15.2	0.3	0.2	0.8	1.3	23.5	98	33	-300	-550	95/91
Aug-98	1	25.8	0.3	0.1		3.2	24	99	67		-3100	/88
Sep-98	3	30.8	0.9	0.2	2.4	1.8	21.4	97	78		-800	92/94
Oct-98	5	25.7	1.2	0.7	2.2	0.7	14.9	95	42	-214	0	91/97
Nov-98	2	30.1	0.9	0.4	0.3	1.6	9		56	25	-300	99/95
Jan-98	2	16.1	16.7	11.9		11.2	5.6	-4	29		6	/30
Feb-98	3		8.7	7.2			3		17			
Mar-98	2		1.9	0.4			8.4		79	100		
1* = Sewer Effluent												
2* = Lagoon Effluent												
3* = OFF Effluent												
4* = FWS Effluent												
5* = SFS Effluent												
(-) Negative Number= Percent Increase												

Table 3 - NH_3-N Removal Summer Performance Data (1998)

DATE	Lagoon Influent MG/L	Lagoon Effluent MG/L	Overland Effluent MG/L	Wetland Effluent MG/L	Percent Removal %
May 26	12.5	4.9	1.1	1.9	85
June 8	17.9		7.9	6.4	64
June 15	8.9	4.2	0.1	0.2	97
June 24	3.7	0.5	0.3	0.4	89
July 1	15.2	6.2	0.1	1.1	93
July 15	9.2	0.4	0.2	0.5	94

Wastewater temperature range 15-27 °C

Table 4 – Total Phosphorus

Month	No. of Samples	Total Phosphorus (mg/L)					Average Temp. (C)	% Red Lagoon	% Red OFF	% Red. FWS	% Red. SFS	Total % Red. FWS/SFS
		1*	2*	3*	4*	5*						
Jul-98	2	3.8	2.1	3.5	3.2	3	23.5	45	-67	9	14	16/21
Aug-98	1	5.8	0.3	0.1	3.2	3.2	24	95	67		-3100	/45
Sep-98	3	12.2	3.4	1.4	3.4	2.8	21.4	72	59	-143	-100	72/77
Oct-98	5	8.1	3.8	1.5	2.7	3.1	14.9	53	61	-80	-107	67/62
Nov-98	2		2	0.4		1.6	9		80	100	-300	
Jan-98	2	2.4	2.7	1.4		1.5	5.6	-13	48		-7	/38
Feb-98	3	5.4	2.2	1.3			3	59	41			
Mar-98	2		1.8	0.8	0.68		8.4		56	15		
1* = Sewer Effluent												
2* = Lagoon Effluent												
3* = OFF Effluent												
4* = FWS Effluent												
5* = SFS Effluent												
(-) Negative Number= Percent Increase												

1*=Influent, 2*= Lagoon Efluent, 3*= OFF Efluent, 4* = OFF Efluent, 5*= Efluent, (-) Negative Number + Percent

Table 2 - Phosphorus Removal Summer Performance Data (1998)

DATE	Lagoon Influent MG/L	Lagoon Effluent MG/L	Overland Effluent MG/L	Wetland Effluent MG/L	Percent Removal %
May 26	0.9	0.4	0.8	0.9	0
June 8	1.8	1.8	2.0	2.5	-39
June 15	2.4	2.1	2.6	2.5	-4
June 24	8.2	1.8	1.7	1.8	79
July 1	3.8	2.2	3.5	3.6	5
July 15	3.2	2.0	3.5	2.5	22

Wastewater temperature range 15-27 °C

Table 2 - PH

Summer Performance Data (1998)

DATE	Lagoon Influent	Lagoon Effluent	Overland Effluent	Wetland Effluent
May 26	7.5	7.7	7.0	6.9
June 8	7.3	7.7	5.9	6.9
June 15	7.6	7.5	7.3	7.1
June 24	7.5	8.2	7.1	6.8
July 1	7.1	8.5	6.9	6.7
July 8	7.0	8.2	7.0	6.7
July 15	7.4	8.8	7.5	7.2

Table 2 - DO Summer Performance Data (1998)

DATE	Lagoon Influent MG/L	Lagoon Effluent MG/L	Overland Effluent MG/L	Wetland Effluent MG/L
May 26	5.0	4.5	5.2	2.0
June 8	4.9	4.5	4.5	2.2
June 15	4.6	2.4	5.8	1.8
June 24	4.8	2.0	2.6	2.2
July 1	2.8	3.5	1.5	1.0
July 8	2.6	1.9	2.7	0.9
July 15	2.7	3.5	3.6	1.4

Table 2
1997 Effluent Quality Data

MONTH	BOD_5, mg/L	SS, mg/L
February	10	15
March	6	7
April	8	21
May	7	4
June	6	10
July	8	12
September	15	15
October	7	13
November	8	9
Average	**8.3**	**11.8**

Sustainability

- Technically Viable
- Economically feasible
- Socially acceptable
- Environmentally and ecologically protective.

Conclusion

- The combined treatment system comprising of waste stabilization ponds, overland flow and wetlands provided an excellent treatment of municipal wastewater.
- Addition of overland flow and wetland wastewater treatment system did have direct benefits to improving the quality of the effluent from the lagoon treatment system.
- In warm weather, the BOD_5 and SS removals ranges were 86-96% and 95-96%, respectively.

Conclusion (continued)

- The summer ammonia nitrogen removal range was 64-94 percent with effluent ammonia-nitrogen range of 0.2-6.4 mg/L which indicates substantial nitrification by the treatment system.
- There was not much change in total phosphorus levels in the treatment system.
- Regardless of seasonal conditions, the effluent BOD_5 and SS for the system met the NPDES effluent permit requirements throughout the year.
- It is expected that the results from this study will be helpful to upgrade many existing waste stabilization pond systems in the Midwest which are experiencing problems meeting the effluent requirements.


NO
TRESPASSING
SEWAGE TREATMENT WORKS
City of STURGEON